IVM Institute for Environmental Studies

VU University Amsterdam

ECONADAPT

The Economics of Adaptation

Funded by the European Union

Paolo Scussolini
Onno Kuik
Elisa Sainz de Murieta
Ibon Galarraga
Kateřina Kaprová
Jan Melichar
Manuel Lago
Josselin Rouillard
Jenny Troeltzsch
Alistair Hunt
Michalis Skourtos
Clare Goodess
Ole Bøssing Christensen

ECONADAPT

Policy workshop

Brussel

September 28th 2016

Economics of project appraisal

Charles University Prague, BC3, ECOLOGIC, University of Bath, Agricultural University of Athens, University of East Anglia, Danish Meteorological Institute

Rationale and objectives

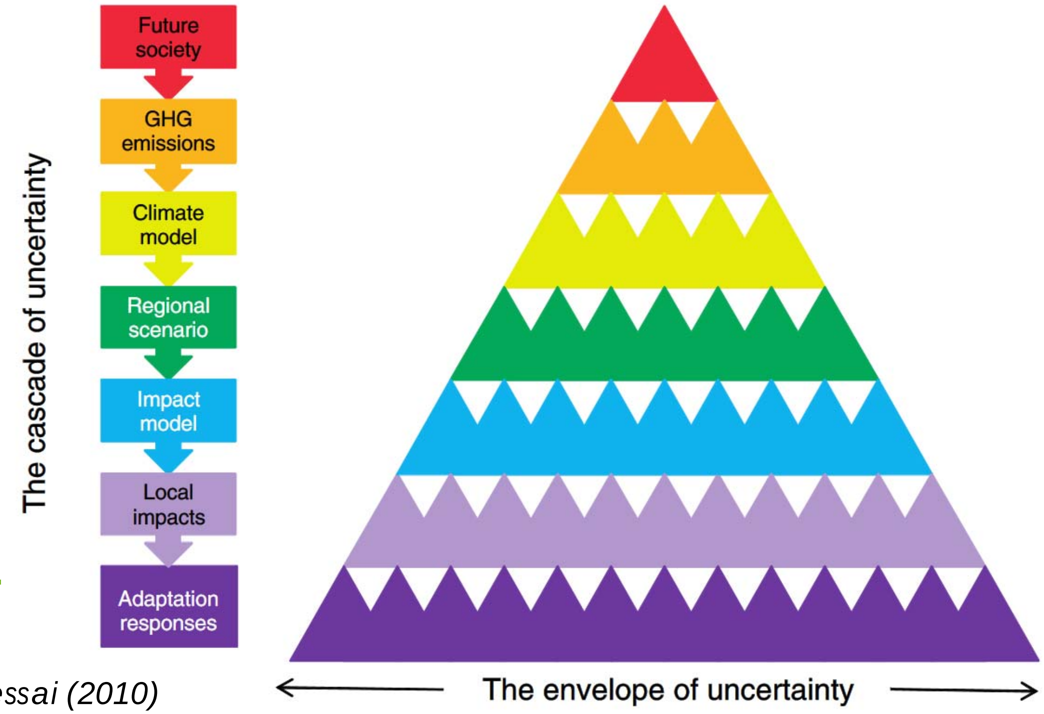
ECONADAPT
The Economics of Adaptation
Funded by the European Union

Consideration of adaptation in infrastructure project appraisal is increasingly required (EUFIWACC; other banks globally; insurers…)

Gap: clear, simple and actionable guidelines, especially for infrastructure investments into adaptation

OBJECTIVE: Use two real-world cases → Prague (CZ) / Bilbao (ES)

→ Generalize and summarize the lesson-learnt into guidelines for appraisals of investment into large Infrastructure and into adaptation

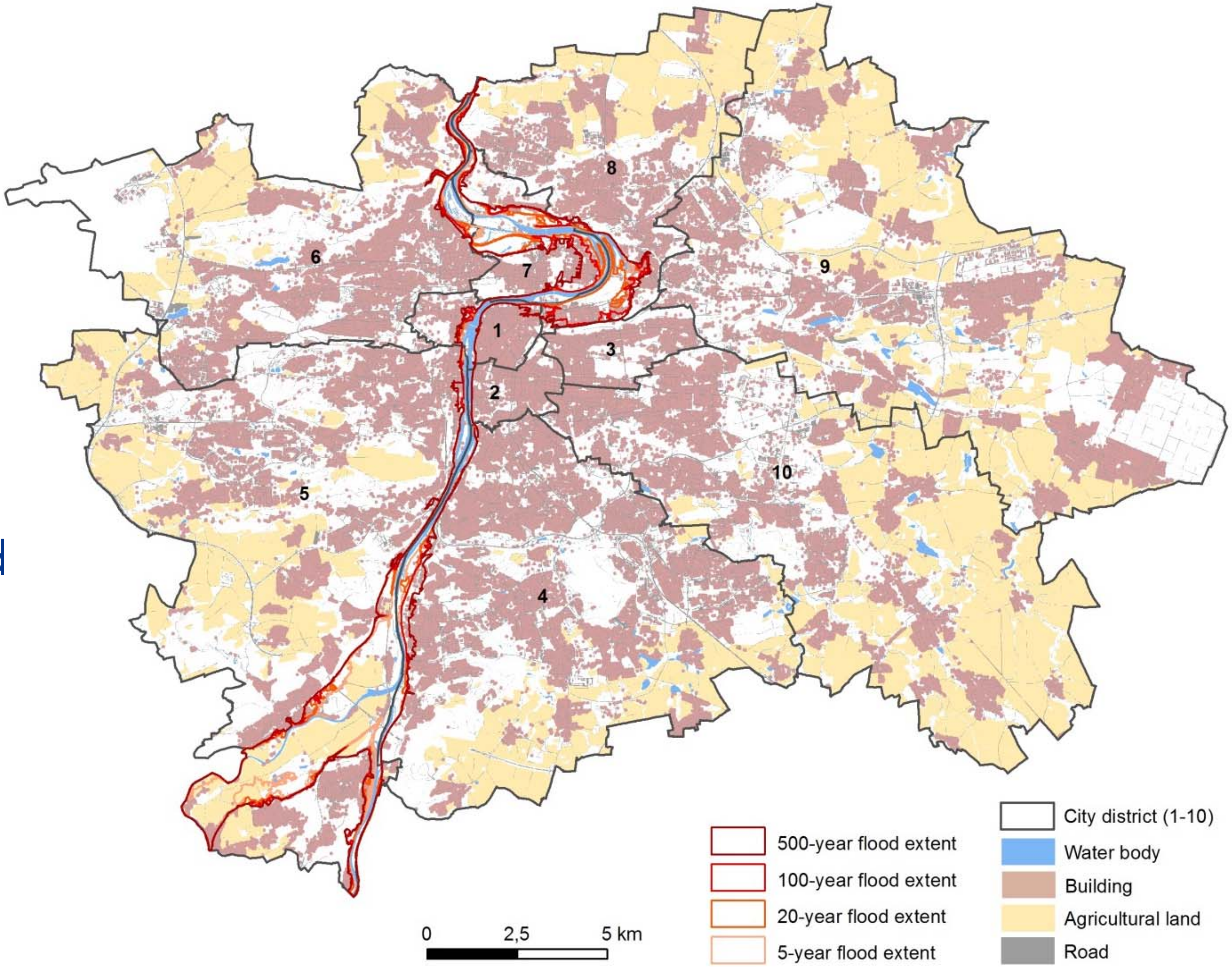


Wilby and Dessai (2010)

IVM Institute for Environmental Studies

Prague case study

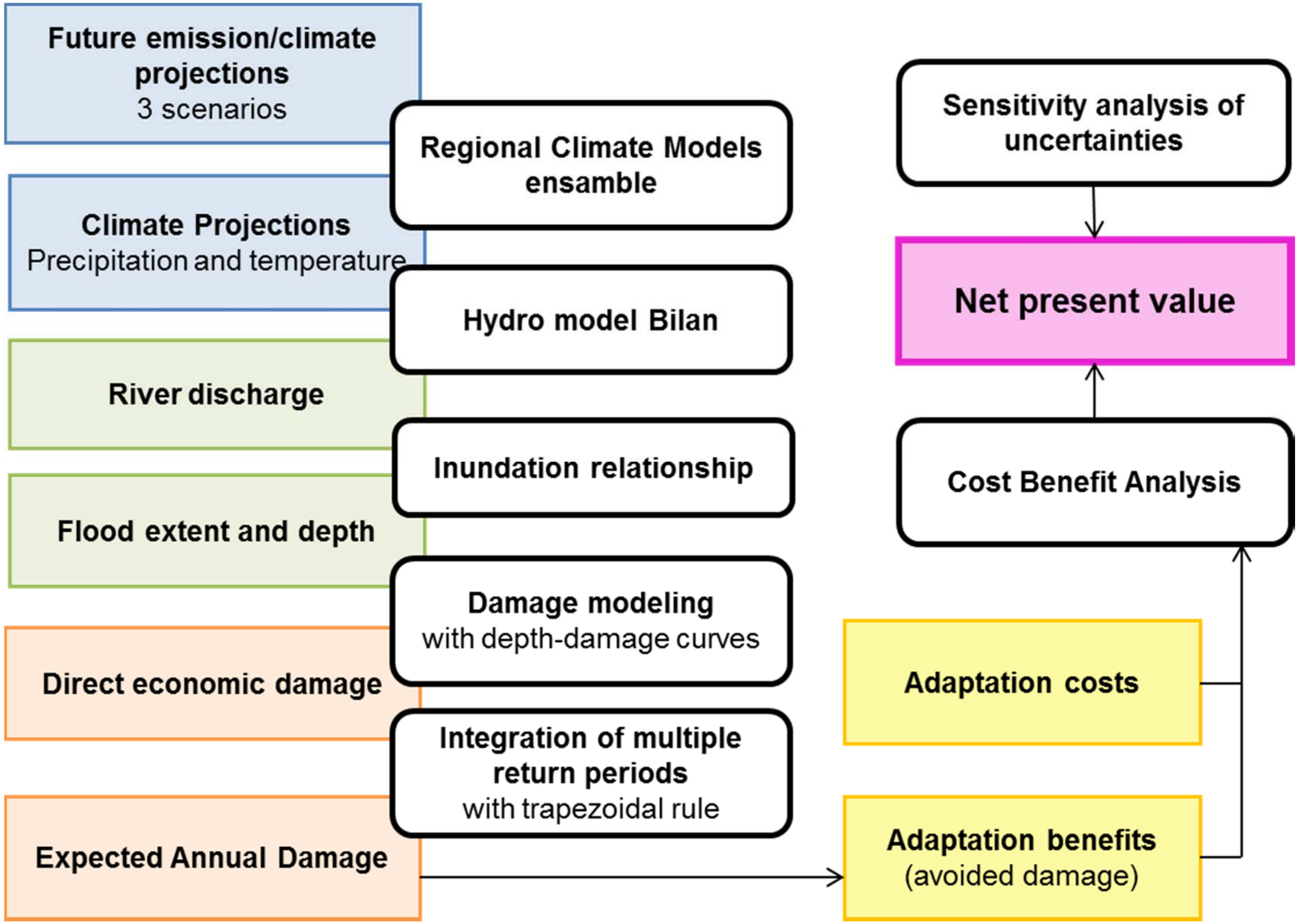
- Vltava river
- Frequent floods
- 4% of EU Solidarity Fund (e.g., 130 M€ in 2002)



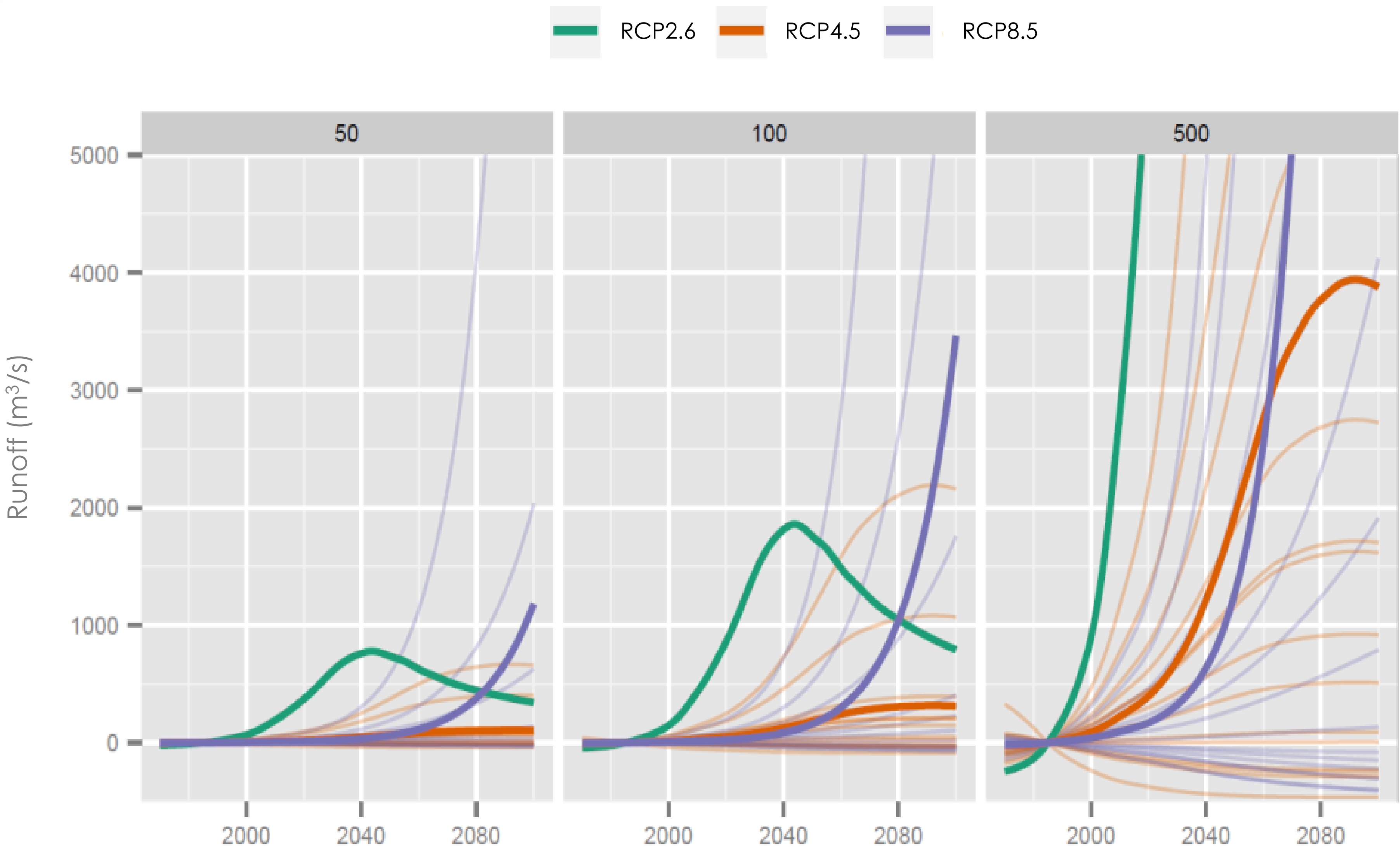
Prague case study

ECONADAPT
The Economics of Adaptation
Funded by the European Union

Ex-post appraisal of investments in adaptation to flooding (1999-2014)



Prague case study



Prague case study

Damage to immovables:
- buildings
- infrastructure

Loss of agricultural production

<table>
<tr><th>Return period</th><th>5-year</th><th>20-year</th><th>50-year</th><th>500-year</th></tr>
<tr><td>Estimated average damage (M€)</td><td>2.8</td><td>47</td><td>85</td><td>597</td></tr>
<tr><td>Actual historic damage (2002-13) (M€)</td><td>0.8</td><td colspan="2">81</td><td>570</td></tr>
</table>

$$D_{total(e)} = D_{build(e)} + D_{road(e)} + D_{crop(e)}$$

Risk as Expected Annual Damage (EAD):

$$EAD = \frac{1}{2}\sum_{i=1}^{n}\left(\frac{1}{RP_i} - \frac{1}{RP_{i+1}}\right)(D_i + D_{i+1})$$

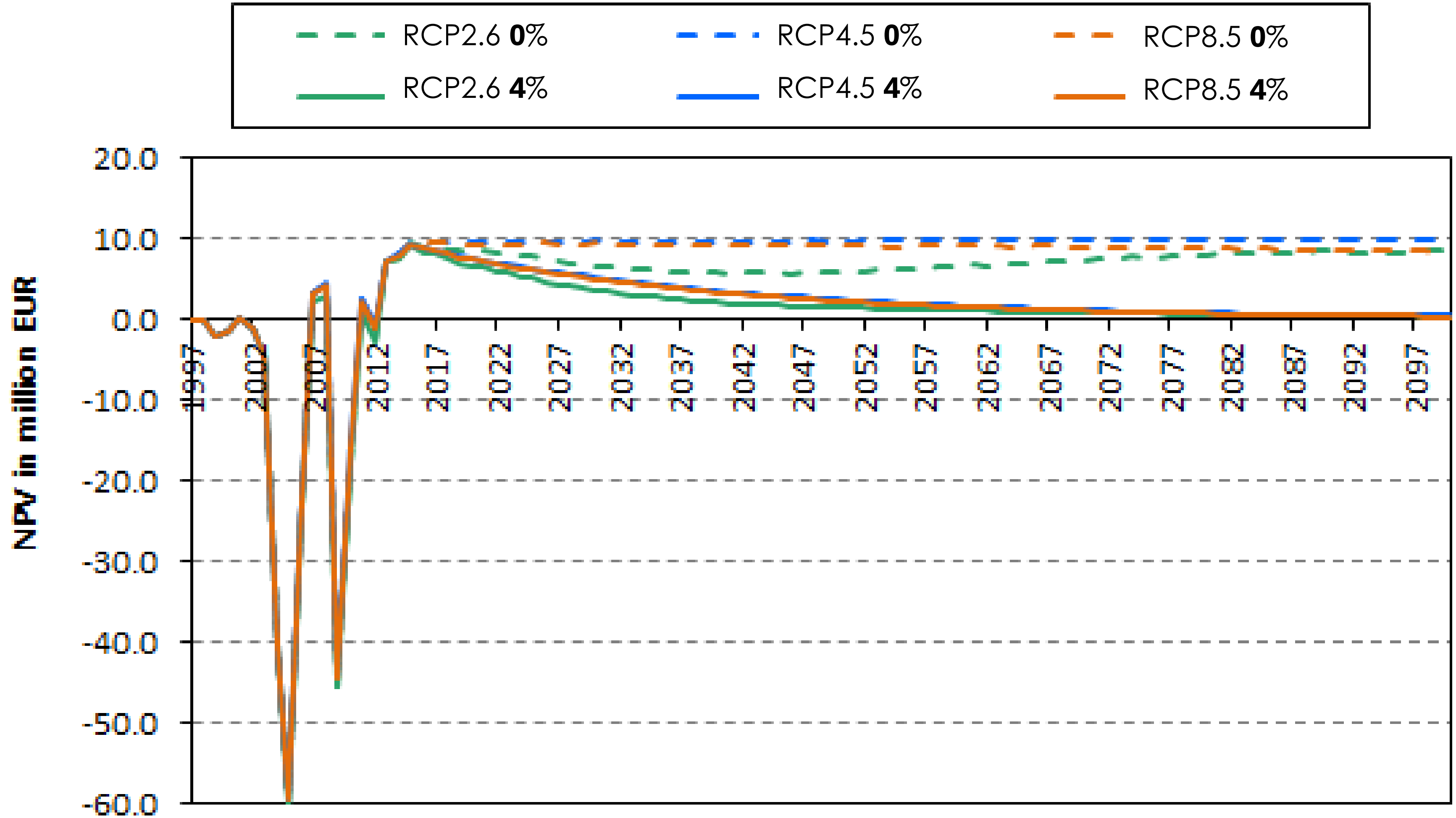
Prague case study

Four approaches to discounting:

- Constant discount rate (0, 1, 2, 3 and 4%)
- Standard neoclassical Ramsey formula $r_s = \delta + \eta \cdot g_t$
- Extended Ramsey formula with stochastic growth $r_s = \delta + \eta \cdot \mu - \eta^2 \cdot \frac{\sigma^2}{2}$
- Discounting under Relative Intertemporal Risk Aversion

$$r_s = \delta + \eta \cdot \mu - \eta^2 \cdot \frac{\sigma^2}{2} - RIRA \cdot |1 - \eta^2| \cdot \frac{\sigma^2}{2}$$

Prague case study



Prague case study

ECONADAPT
The Economics of Adaptation
Funded by the European Union

Uncertainty treatment: Sensitivity study to attribute relevance of sources of uncertainty on the CBA results

Input parameter	Realizations	Source of uncertainty
Representative Concentration Pathways	3	Difference in the GHG forcing boundary conditions
Climate simulations from RCM	14	Assumptions behind the regional climate models
Depth-damage function	3	Variability in the damage rates
Approximation of EAD	2	Trapezoidal rule with different number of return periods
Variable costs	3	Range of values
Lump-sum costs	3	Range of values
Economic growth	10	Variability in the GDP growth projections, different SSPs and models
Discounting approach	4	Assumptions behind discounting

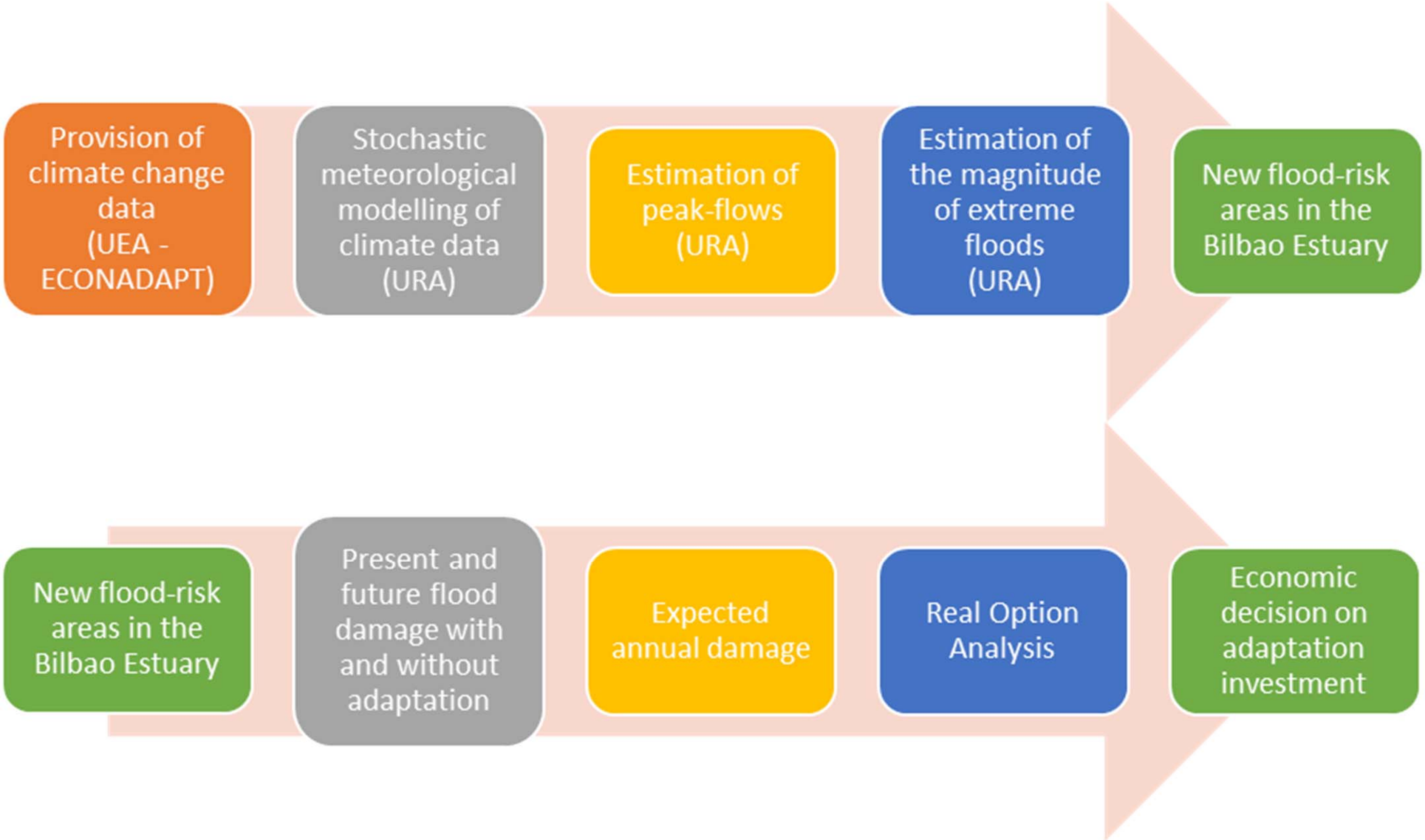
$\Delta B = \Delta NPV$ generally > 0 (≈ Ms €)

Discounts of 4% and above entail $\Delta NPV < 0$

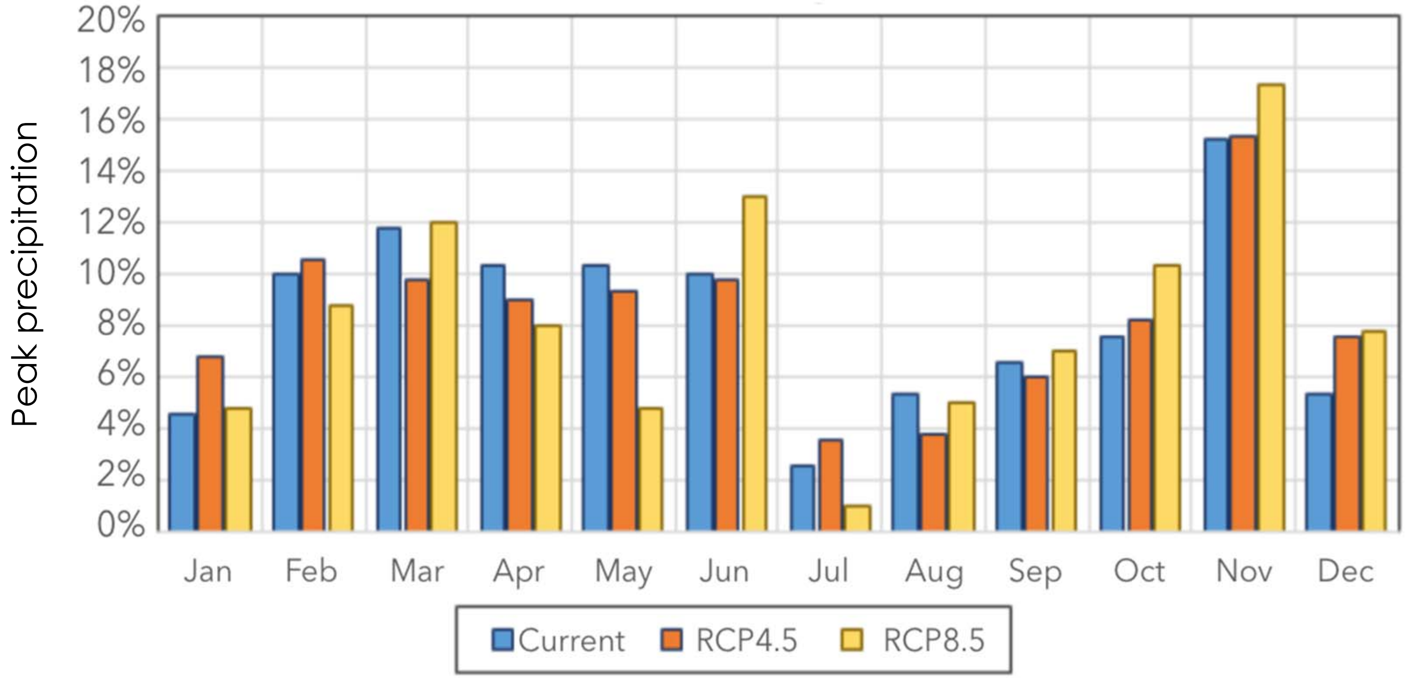
Appraisal of investment in flood reduction – Real Option Analysis

Measure: opening a canal → turning Zorrotzaurre into peninsula

Bilbao case study



Bilbao case study



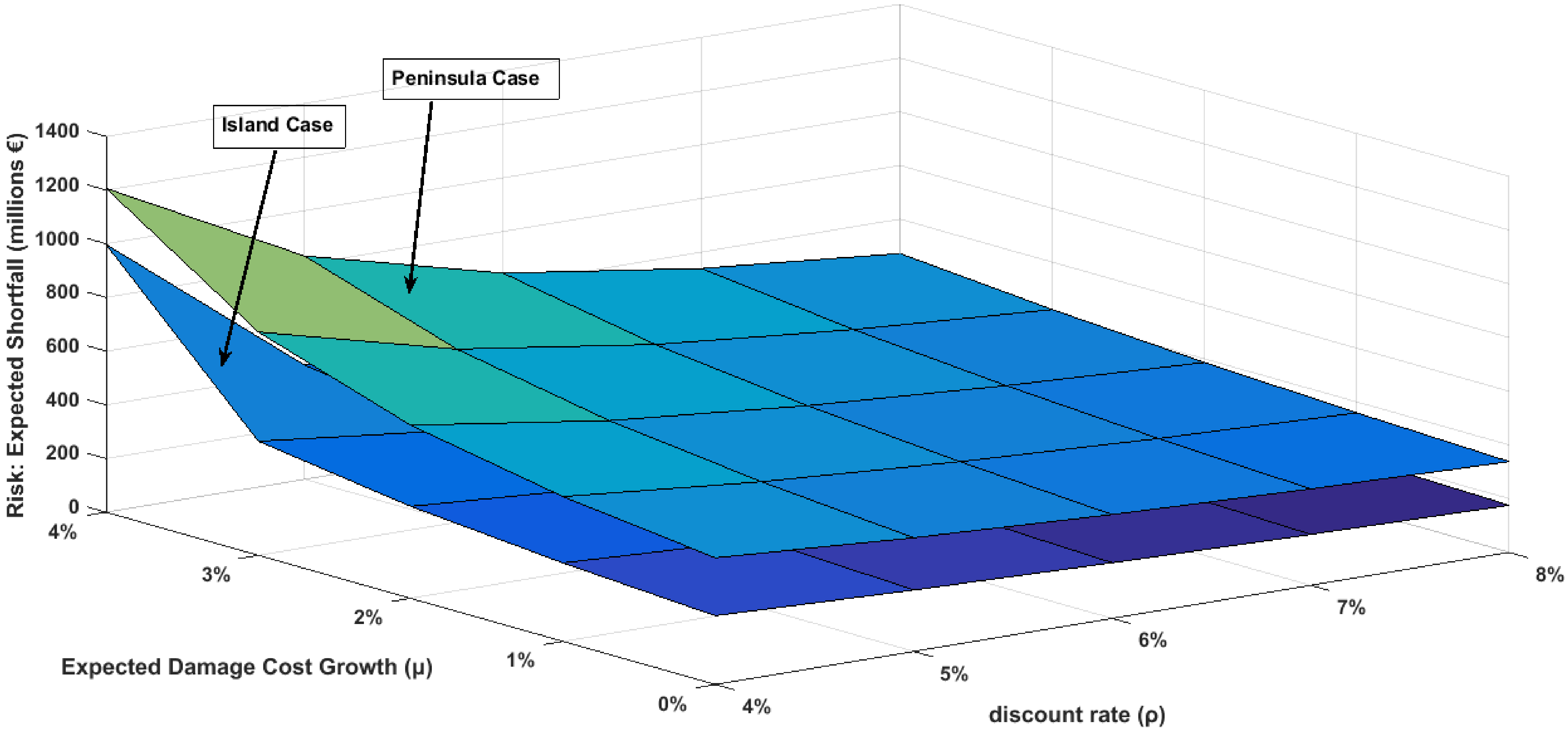
+ sea level anomalies considering future rise

Five categories of damage:

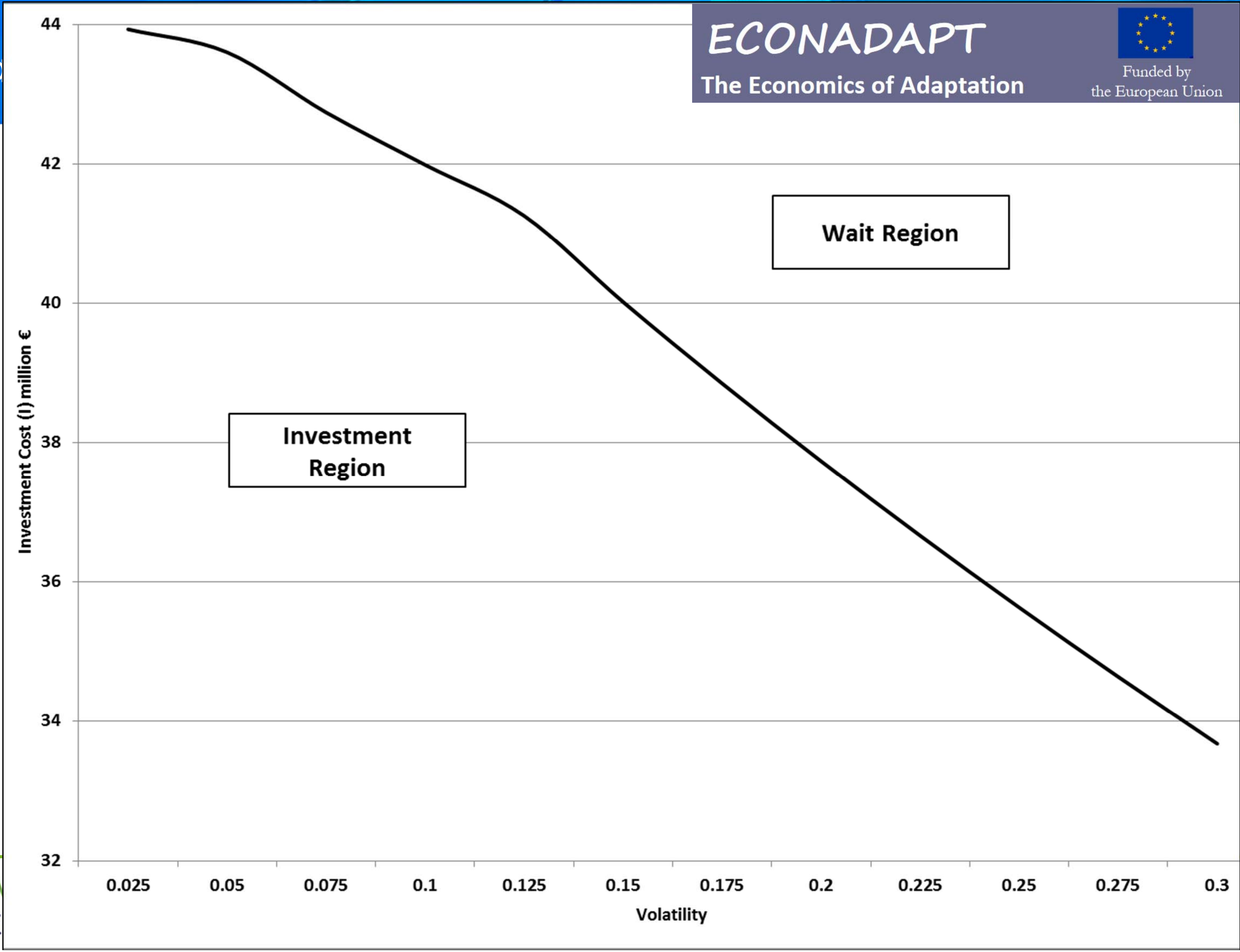
1. damages to residential property
2. relocation costs
3. impacts on cultural heritage
4. impacts on human health
5. disruption of transportation, increase in emergencies, and second -round effects

ECONADAPT
The Economics of Adaptation
Funded by the European Union

Risk metrics used: Value at Risk; Expected Shortfall; Volatility



Bilbo


ECONADAPT
The Economics of Adaptation
Funded by the European Union
Investment Cost (I) million €
44
42
40
38
36
34
32
Wait Region
Investment Region
0.025
0.05
0.075
0.1
0.125
0.15
0.175
0.2
0.225
0.25
0.275
0.3
Volatility

Uncertainty study

ECONADAPT
The Economics of Adaptation
Funded by the European Union

Source of uncertainty	How is it addressed?		Degree of uncertainty	
	Prague	Bilbao	Prague	Bilbao
Future emissions	Use of three RCPs: RCP 2.6; RCP 4.5; RCP 8.5	Use of two RCPs: RCP 4.5; RCP 8.5	Medium	Medium
Regional climate	Use of 14 climate simulations from several RCMs for precipitation and temperature	Use of 11 climate simulations from several RCMs for precipitation and temperature; for sea level rise a regionalization of IPCC mean global sea level change	**High**	**High**
Hydrological modeling	Cut-off of the events with the highest return periods, to reduce uncertainty from the extrapolation of extreme values from limited observation series	Not addressed	Low	
Socio-economic developments	Application of SSP- and RCP-dependent discount rates for future values. Also, two different sources of GDP projections are used (OECD, IIASA)	Results are provided for a range of values of increase in damage, also reflecting socioeconomic development	**High**	**High**
Damage calculation	Inclusion of uncertainties on exposure of assets and on the vulnerability curves for buildings: min, max and mean values are considered for these datasets	Inclusion of min and max values for the maximum possible damage to buildings	Medium/ High	Medium/ High
Costs of adaptation	Inclusion of a range of values for the cost of maintenance and for "one-off" costs for protection operations	Results of the decision-making process are provided for a range of values of investment costs	Low	Medium
Method of EAD calculation	Trapezoidal rule using 6 return periods vs. using full range of 141 return periods	Estimation of likelihood of occurrence of stochastic events of three return periods with Poisson process	Medium	Low
Discounting approach	Employing several approaches: constant rate; Ramsey formula with scenario-dependent discount rate; expanded Ramsey formula with uncertain growth; expanded Ramsey formula with RIRA. Also, two different sources of GDP projections are used (OECD, IIASA)	Results are shown for a vast range of discounting values	Medium	Medium
Discount rate	Two discount rates are used for the constant discounting approach	Results are shown for a vast range of discounting values	**Highest**	Medium

IVM Institute for Environmental Studies

Practical guidelines

The two case studies served to identify the key steps and challenges in the appraisal:

1. Generalize (from floods)
2. exploit the range of expertise in ECONADAPT consortium
3. distil guidelines for practitioners

   As straightforward and free of technical jargon as possible

Practical guidelines

Total of **22 steps**, divided in 6 areas:

A. Context analysis
↓
B. Hazard assessment
↓
C. Impact assessment
↓
D. Adaptation
↓
E. Economic appraisal
↓
F. Decision-making with consideration of stakeholders

For each step:

- overview of problem
- state-of-the-art practices and plausible methodological choices
- account of what done in our case studies
- report on pros and cons of what done
- recommend what to do

Summary tables

For each step:

- main strength of the approaches taken in the two case studies,
- remaining challenges
- resulting recommendations

Aim: provide a schematic map with minimal amount of information that the practitioner should keep in mind at any moment

Examples:

Step	Main strengths in our approach	Remaining challenges	Recommendations
B.2 Climate datasets	In the **Prague** case we used climate data from a wide range of climate models, and thus adequately sampled the inter-model uncertainty	For the **Bilbao** case we could only use the results of one climate model. However, we justified this choice by demonstrating that this dataset is representative of multiple models' ensemble mean	Use datasets from multiple models, and sample the range of their outcomes. When limited resources imply that datasets from few model can be used: carefully select the model(s) and provide estimation of the uncertainty around their outcomes

ECONADAPT
The Economics of Adaptation
Funded by the European Union

Examples:

Step	Main strengths in our approach	Remaining challenges	Recommendations
E.5 Discounting of future values	We explored a large variety of approaches to discounting, and of values, in the **Prague** case, also considering their compatibility with the climate scenarios adopted. In the **Bilbao** case, results were produced for any plausible rate of discount	Discounting beyond certain thresholds makes adaptation inefficient	As this step is crucial to the outcome of the economic appraisal, rigorous investigation (i.e., sensitivity analysis) of the effects of different discounting approaches and rates should be carried out

Main recommendations

- The appraisal of infrastructure investments, and the evaluation and planning of adaptation is by its own nature a comprehensive and multidisciplinary exercise. The practitioner should count on (access to) a range of expertise to do the job
- it is possible to structure the appraisal after a set of steps that should be carefully considered and at least inspire the practice

Future research directions

Mismatch between time required for appraisal and time available?

→ Compare approaches, for the key steps:

Test how minimal, light touch approaches perform vs full-blown quantification of impacts

→ Capacity building projects

Thank you

paolo.scussolini@vu.nl